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Running Head: Face Blushing Embarrassment

Facial blushing influences perceived embarrassment and related social functional evaluations

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Abstract

Facial blushing involves a reddening of the face elicited in situations involving unwanted social attention. Such situations include being caught committing a social transgression, which is typically considered embarrassing. While recent research has demonstrated that facial redness can influence social evaluations, including emotional states such as perceived anger, the influence of blushing on social perceptions related to embarrassment or social transgression has yet to be investigated. Across three experiments, we manipulated the redness of neutral faces (Exp. 1) and faces displaying different emotional expressions (Exps. 2 and 3), and had participants evaluate perceived embarrassment, apology sincerity, and likeliness to forgive a transgression for each set of stimuli. Results indicated that redder (relative to baseline) faces influenced perceived embarrassment, apology sincerity, and likeliness to forgive a transgression. We discuss the implications in the context of a social functional account of facial color in emotion expression and perception.

Keywords: Blushing, Face Color, Embarrassment, Social Function.

Facial blushing influences perceived embarrassment and related social functional evaluations

Blushing involves a reddening of the face elicited in situations involving unwanted social attention (Darwin, 1872; Leary & Meadows, 1991). The blush is a defining feature of embarrassment (Buss, 1980), and definitions of the word ‘red’ include references to the face changing color as a result of experiencing embarrassment (i.e., Oxford English Dictionary). The reddening of the face is due to a rapid vascular response that distributes blood flow to facial skin areas (Cooper & Gerlach, 2012; Drummond, 2012). Individuals blush during situations in which there is a chance of being negatively evaluated by others (De Jong & Dijk, 2013; Leary, Britt, Cutlip, & Templeton, 1992). Such situations include being caught committing a social transgression, inadvertently causing harm to another, or engaging in embarrassing behaviors.

Social functional accounts of emotion suggest that emotion expressions evolved because of the advantages they confer in solving distinct social problems inherent in the social environment (Keltner, Haidt, & Shiota, 2006). Blushing serves such a social function, in that it communicates to others that we sincerely regret a social transgression, and that we value their social evaluation, therefore appeasing and minimizing social disapproval (Castelfranchi & Poggi, 1990; De Jong, 1999). Such an expression is valuable in the evolutionary history of our species, when social exclusion might have meant a loss of social resources (e.g., food, protection, potential mates) vital to survival and reproduction.

Recent research has demonstrated that changes in facial color can influence a range of social evaluations relevant to adaptive social functioning, including perceived health, attractiveness, dominance and aggression, sex, age, and emotion (Benitez-Quiroz, Srinivasan, & Martinez, 2018; Carrito et al., 2016; Jones, Porcheron, Sweda, Morizot, & Russell, 2016; Lefevre et al., 2013; Matts, 2008; Nestor & Tarr, 2008; Pazda, Thorstenson, Elliot, & Perrett,

2016; Re, Whitehead, Xiao, & Perrett, 2011; Said & Todorov, 2011; Stephen, Coetzee et al., 2009; Stephen et al., 2012; Stephen, Law Smith, Stirrat, & Perrett, 2009; Tarr, Kersten, Cheng, & Rossion, 2010; Thorstenson, Elliot, Pazda, Perrett, & Xiao, 2017; Thorstenson, Pazda, Elliot, & Perrett, 2016; Thorstenson, Pazda, Young, & Elliot, 2018; Young, 2015; Young, Thorstenson, & Pazda, 2016). Further, past research has demonstrated that the blush (instantiated using vignettes that include verbal references to a blush, or with images expressing emotions that include a blush) influence perceptions of embarrassment, prosociality, and likeableness (De Jong et al., 2003; Dijk et al., 2009; Dijk et al., 2011; Feinberg et al., 2012) However, facial redness (independently or jointly with the context of other expressive features) related to situations that may evoke a blushing response of an individual and its influence on social functional evaluations of forgiveness and apology sincerity has yet to be investigated.

In the current research, we manipulate facial redness and assess participants' perceptions of embarrassment and related social functional evaluations. In Experiment 1, we present pairs of neutrally expressive facial images (baseline vs. redder faces), along with brief vignettes that indicate a social transgression has occurred, and we ask participants to select the faces that look more embarrassed, more sincere in apology, and are more likely to be forgiven. Perceived embarrassment was assessed as our focal evaluation because the blush is elicited in situations involving unwanted social attention, which are typically considered embarrassing. Moreover, we chose to focus on perceived apology sincerity because we hypothesize that one social function of the blush is to convey a signaler's 'honest' intentions (Crozier, 2006), independent from facial-muscular expressions. Finally, we chose to assess likeliness to forgive a transgression because it reflects a functional behavioral response found to be evoked in response to nonverbal displays of embarrassment (for an overview, see Keltner, & Buswell, 1997). In Experiment 2, we

additionally include face-pairs that express embarrassment and shame, while assessing the same social perceptions along continuous rating scales. In Experiment 3, we include face-pairs that express shame and anger, while assessing these social perceptions along continuous rating scales. Across Experiments 1 and 2, we expect redder faces (representing a blush) to be perceived as more embarrassed, more sincere in apology, and more likely to be forgiven. In Experiment 3, we expect redder faces to facilitate these social evaluations to greater extent for shame expressions than for anger expressions.

In line with Simmons, Nelson, and Simonsohn's (2012) suggestions for both experiments, all data exclusions, manipulations, and variables analyzed are reported, and data collection was completed prior to any analysis. All participants were unique (each individual only participated in one experiment). All analyses included only participants with color-normal vision, assessed by self-report at the end of each experiment; participants that reported a color vision deficiency were excluded from all analyses *a priori*. In all experiments, target sample size (target $n = 90$) was determined *a priori* via power analysis (targeting .80 power to detect a $d = .30$ effect at $p < .05$), which we were able to slightly exceed in all experiments (Exp. 1 $n = 97$; Exp. 2 $n = 110$; Exp. 3 $n = 93$) due to participant availability.

Experiment 1

Method

Participants. Ninety-seven (61 female, $M_{age} = 20.05$, $SD_{age} = 1.22$) students at a university in the northeast US with color-normal vision participated in the experiment in exchange for extra course credit.

Stimuli. We used 8 images (4 male, 4 female) that were composite faces of multiple individual photographs. Matlab was used to adjust the original images by +5 units in CIELAB a^*

(redness). Photoshop was used to generate face-shaped masks to ensure that the color change was restricted to skin areas of the face (i.e., excluding the hair, eyes, teeth, clothing, and background). This resulted in 2 images for each face: a baseline and redder face. See Figure 1 for an example of the stimuli used in Experiment 1.

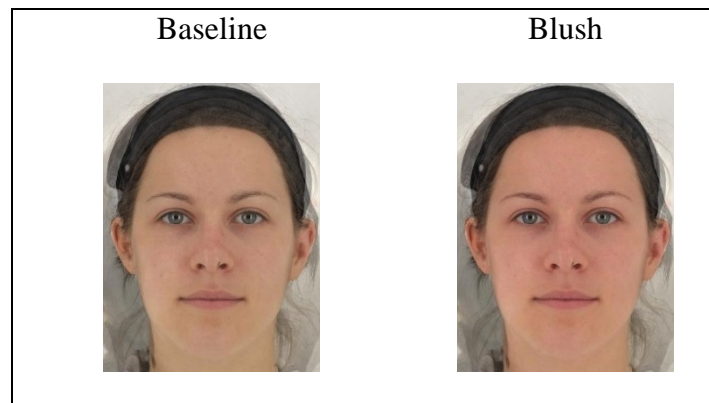


Figure 1. Example stimuli used in Experiment 1.

Procedure. Participants completed the experiment on a CRT monitor, color-calibrated using an i1-pro spectrophotometer (achieved monitor specifications were D65, $x = .31$, $y = .33$, $Y = 120$ cd/m²). The viewing distance was approximately 55 cm and the viewing angle was approximately 0° - 15°. The display background was white, and the monitor surround was black. The room was dimly lit. Participants completed three separate blocks, one for each of the focal evaluations (embarrassment, apology sincerity, and forgiveness). For each block, participants read a short vignette related to the respective evaluation, and were asked to choose between two simultaneously presented images (baseline vs. redder face) by clicking on the face to record their response. In the embarrassment block, participants were prompted with the vignette, “You catch these people telling a lie. Which face looks more embarrassed?”. In the sincerity block, participants were prompted with the vignette, “These people apologize for cheating on a test. Whose apology is more sincere?”. In the forgiveness block, participants were prompted with the vignette, “These people borrow your most valuable possession and then lose it. Who would you

be more likely to forgive?”. Participants made a selection for each pair of faces for each block, for a total of 24 trials. Block order, face order within blocks, and side of screen (redder face on left vs. right) were randomized.

Results

Composite scores were computed by averaging the face selections (baseline face selection coded 0, redder face selection coded 1), separately for each block, representing the proportion of redder versus baseline face selections. One-sample t-tests were conducted against a test-value of 0.5 (chance) to assess whether participants selected redder (vs. baseline) faces at higher than chance level for each of the evaluations. The results indicated that participants perceived blushing faces as being more embarrassed ($M = 0.81$, $SD = 0.28$), $t(96) = 11.114$, $p < .001$, $d = 2.27$, more sincere in apology ($M = 0.63$, $SD = 0.33$), $t(96) = 3.827$, $p < .001$, $d = .78$, and participants indicated that they would be more likely to forgive individuals with blushing faces ($M = 0.61$, $SD = 0.35$), $t(96) = 3.116$, $p = .002$, $d = .64$.¹

Experiment 2

Experiment 1 demonstrated that facial blushing facilitated perceptions of embarrassment, apology sincerity, and likeliness to forgive a transgression, relative to baseline faces for neutral expressions. In Experiment 2, we aim to assess the influence of facial blushing on the same social evaluations while additionally introducing two emotional expressions: embarrassment and

¹ We additionally repeated the procedure of Experiment 1 using an online sample and identical methodology. Seventy-nine (39 female, $M_{age} = 35.57$, $SD_{age} = 10.10$) workers with color-normal vision from Amazon’s Mechanical Turk participated in the experiment in exchange for 0.15 USD. As in the laboratory, results from the online study indicated that participants perceived blushed faces as more embarrassed ($M = 0.66$, $SD = 0.30$), $t(78) = 4.796$, $p < .001$, $d = 1.09$, and participants indicated that they would be more likely to forgive individuals with blushed faces ($M = 0.58$, $SD = 0.37$), $t(78) = 2.006$, $p = .048$, $d = .45$. However, there was no significant effect of blushing on apology sincerity ($M = 0.51$, $SD = 0.36$), $t(78) = 0.373$, $p = .71$, $d = .08$.

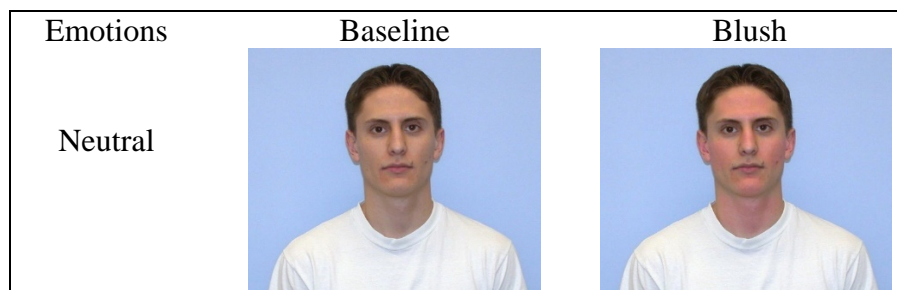
shame. We chose to include these expressions in order to assess whether facial blushing would influence perceptions of embarrassment and related social functional evaluations over and above emotional expressions. It may be the case that embarrassed or ashamed emotional expressions are sufficient to convey the respective social states and overwrite the influence of blushing on people's perceptions. However, if facial blushing can influence people's social evaluations independently of these facial-muscular emotion expressions, then it would provide evidence that facial blushing conveys unique or additive information important for social perception in the case of embarrassment and related social evaluations.

Method

Participants. One-hundred-ten (86 female, $M_{age} = 20.19$, $SD_{age} = 1.35$) students at a university in the northeast US with color-normal vision participated in the experiment in exchange for extra course credit.

Stimuli. We selected two stimulus photographs (1 male, 1 female) from the University of California-Davis Set of Emotion Expressions (Tracy, Robins, & Schriber, 2009). Each individual was photographed posing a neutral, embarrassed, and ashamed facial expression. For each photograph, we created 2 versions varying in facial redness by +10 units in CIELAB a^* (redness) in the same way as in Experiment 1. We chose to manipulate facial redness by +10 units (instead of +5 units as in Experiment 1) because these images had lower resolution and more variable lighting conditions (due to posture and gaze direction), so we wanted to ensure that the redness change was clearly visible across emotional expressions. This resulted in a total of 12 stimulus photographs (2 targets \times 3 expressions \times 2 color conditions). See Figure 2 for an example of the stimuli used.

Procedure. Participants completed the experiment on a CRT monitor with the same color-calibration and laboratory conditions described in the previous experiment. Participants completed three separate blocks, one for each of the focal evaluations (embarrassment, apology sincerity, and forgiveness). In each block, a pair of faces from the same target identity (baseline vs. increased redness) was displayed side-by-side on the monitor, along with the vignettes used in the previous experiment. Specifically, in the embarrassment block, participants were prompted with the vignette, “You catch this person telling a lie. How embarrassed does this person look?”. In the sincerity block, participants were prompted with the vignette, “This person apologizes for cheating on a test. How sincere is this person’s apology?”. In the forgiveness block, participants were prompted with the vignette, “This person borrowed your most valued possession, and then lost it. How likely would you be to forgive this person?”. Participants provided ratings for each stimulus photograph on a scale of 1 (not at all) to 9 (very much) on each of the questions for each block. Participants rated each target photograph for each color condition across all three facial expressions, resulting in 36 total trials. Target identity, order within blocks, and side of screen (redder face on left vs. right) were randomized. The perceived embarrassment block was completed first, then the sincerity and forgiveness blocks followed in randomized order.



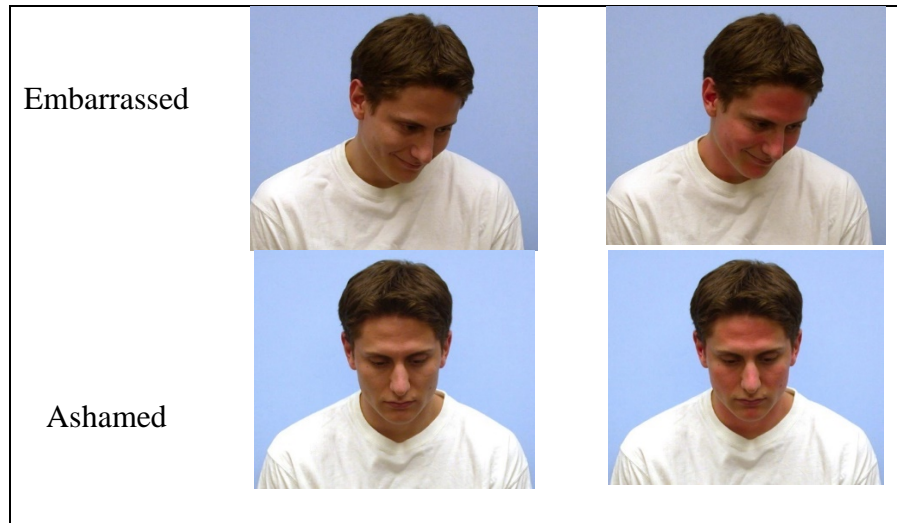


Figure 2. Example stimuli used in Experiment 2.

Results

We conducted $3 \times 2 \times 2$ repeated measures ANOVAs (expression: neutral, embarrassed, ashamed \times color: neutral, red \times target identity) for each type of judgment.

Embarrassment. A main effect of facial expression emerged, $F(2, 218) = 90.80, p < .001, \eta_p^2 = .45$. Pairwise comparisons indicated that faces exhibiting an embarrassed or ashamed expression were perceived as more embarrassed than faces exhibiting a neutral expression (Figure 3). Additionally, there was a main effect of target identity, $F(1, 109) = 23.62, p < .001, \eta_p^2 = .18$. More central to our hypotheses, a main effect of color emerged, $F(1, 109) = 245.94, p < .001, \eta_p^2 = .69$, such that blushed faces were perceived as more embarrassed ($M = 5.58, SE = .15$) than baseline faces ($M = 3.29, SE = .11$). The effect of blushing did not interact with facial expression ($F = .24, p = .79$) suggesting that emotions and blushing independently influenced people's evaluations of facial stimuli. No other interactive effects were observed.

Apology sincerity. A main effect of facial expression on apology sincerity emerged, $F(2, 218) = 280.23, p < .001, \eta_p^2 = .72$. Pairwise comparisons indicated that faces exhibiting a shame

expression were perceived as most sincere, followed by neutral, and then by embarrassed faces (Figure 3). There was also a main effect of target identity, $F(1, 109) = 38.62, p < .001, \eta_p^2 = .26$. Central to our hypotheses, a main effect of color emerged, $F(1, 109) = 21.86, p < .001, \eta_p^2 = .17$, such that blushed faces were perceived as more sincere ($M = 4.01, SE = .12$) than baseline faces ($M = 3.49, SE = .10$). The effect of facial redness on perceived apology sincerity did not differ as a function of facial expression ($F = .40, p = .67$).

Likelihood to forgive. A main effect of facial expression emerged, $F(2, 218) = 233.88, p < .001, \eta_p^2 = .68$. Pairwise comparisons indicated that participants were more likely to forgive individuals exhibiting a shame expression than individuals exhibiting embarrassed or neutral expressions (see Figure 3). There was also a main effect of target identity, $F(1, 109) = 47.53, p < .001, \eta_p^2 = .30$. Central to our hypotheses, a main effect of color emerged, $F(1, 109) = 68.14, p < .001, \eta_p^2 = .39$, such that participants were more likely to forgive individuals with blushed faces ($M = 4.08, SE = .15$) than individuals with baseline facial coloration ($M = 3.39, SE = .14$). The effect of blushing on likelihood to forgive was different across facial expressions ($F = 5.04, p = .007, \eta_p^2 = .04$). The difference in likelihood to forgive for blushed versus baseline faces was significant for all expressions, though it was greater for neutral and shame expressions, relative to an embarrassed expression (see Figure 3).

Mediation analyses. Next, we tested whether perceived embarrassment mediated the effects of blushing on apology sincerity and willingness to forgive. We computed composite scores that averaged participant ratings for each dependent variable, collapsing across target identity and facial expression. Then we used *MEMORE* (Montoya & Hayes, 2017) for SPSS to explore indirect effects of blushing on sincerity/forgiveness via perceived embarrassment.

Ninety-five percent confidence intervals were generated from 5,000 bootstrap samples and are reported in brackets for each result below. See Figure 5 for a summary of the mediation analyses.

Apology sincerity. The total effect of blushing on perceived apology sincerity was significant, ($c = .52$ [.30, .74], $p < .001$), meaning that the targets with increased facial redness, on average, were rated as .52 points higher on sincerity than targets with baseline coloration. The blushing targets were also perceived as more embarrassed than the baseline targets ($a = 2.30$ [2.01, 2.59], $p < .001$). Perceived embarrassment was significantly related to apology sincerity ($b = .26$ [.12, .41], $p < .001$), and the indirect effect of blushing on apology sincerity via perceived embarrassment was significant, ($ab = .60$ [.29, .94], $p < .001$). After accounting for the influence of perceived embarrassment on apology sincerity, facial redness was no longer related to apology sincerity, ($c' = -.09$ [-.47, .30], $p = .65$).

Likeliness to forgive. The total effect of blushing on likeliness to forgive was significant, ($c = .69$ [.53, .86], $p < .001$). The blushing targets were also perceived as more embarrassed than the baseline targets ($a = 2.30$ [2.01, 2.59], $p < .001$). Perceived embarrassment was significantly related to likeliness to forgive ($b = .25$ [.14, .35], $p < .001$), and the indirect effect of blushing on likeliness to forgive via perceived embarrassment was significant, ($ab = .57$ [.35, .81], $p < .001$). After accounting for the influence of perceived embarrassment on likeliness to forgive, blushing was no longer related to forgiveness, ($c' = .12$ [-.16, .40], $p = .39$).

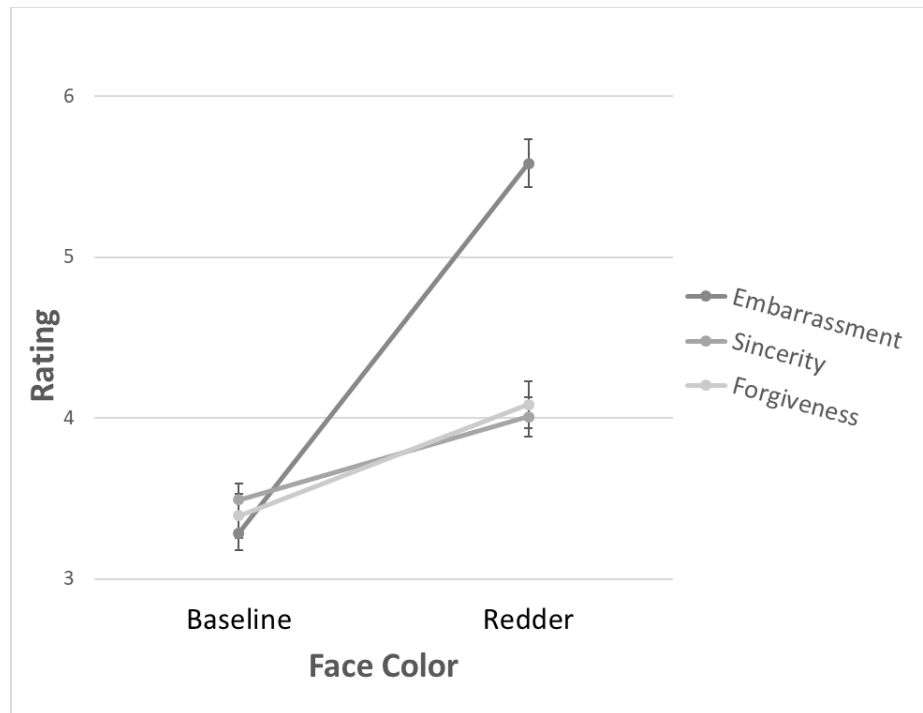


Figure 3. Summary of the effects of facial redness in Experiment 2. Mean and standard error of embarrassment, sincerity, and forgiveness ratings across face color. Blushing faces were perceived as more embarrassed, more sincere in apology, and were more likely to be forgiven.

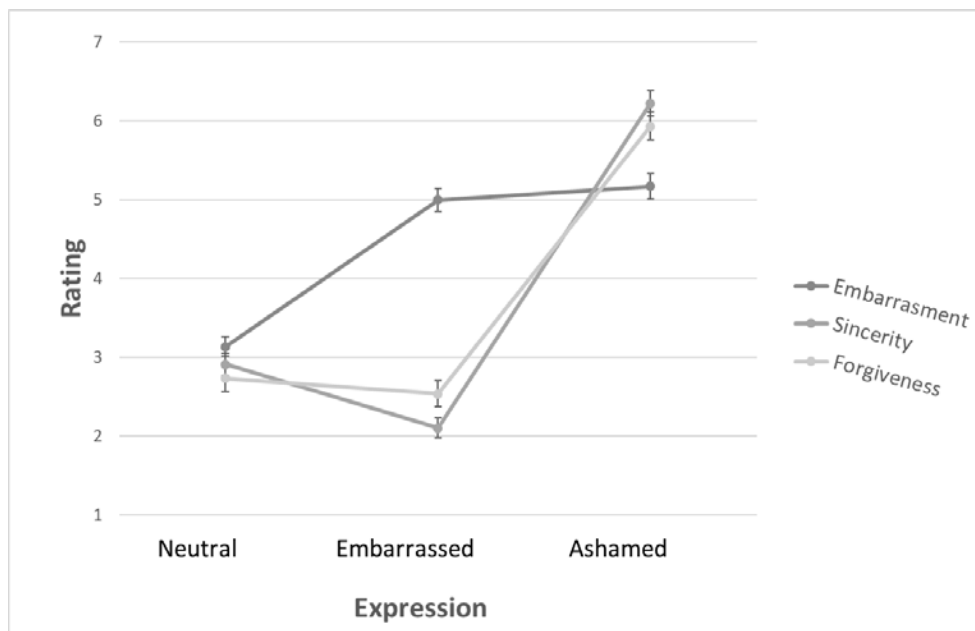


Figure 4. Summary of facial expression effects from Experiment 2. Mean and standard error of embarrassment, sincerity, and forgiveness ratings across facial expressions.

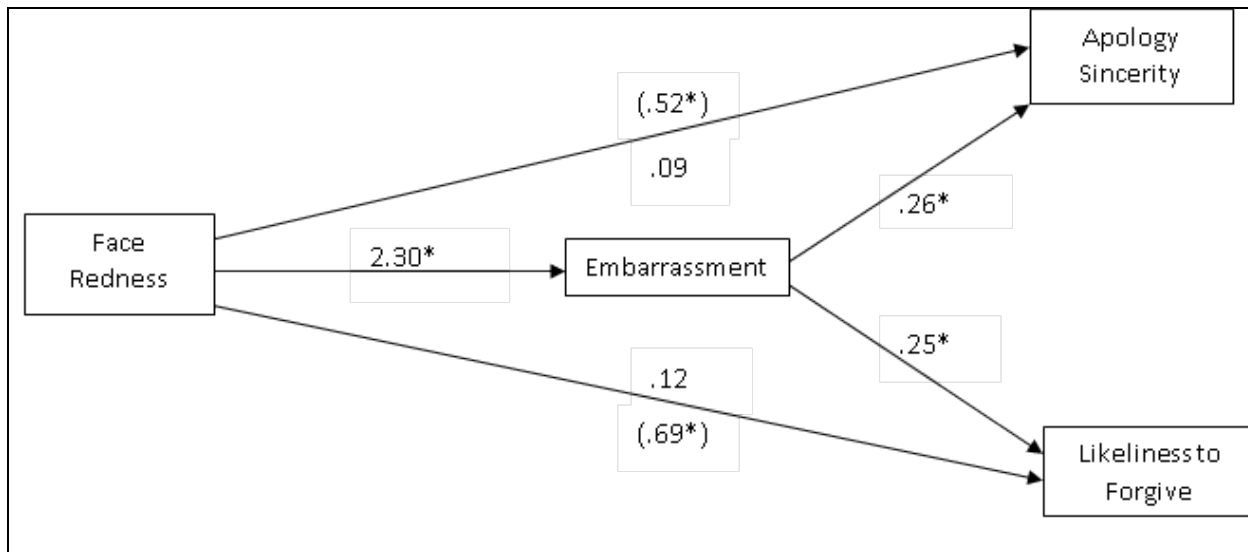


Figure 5. $*p < .001$. Effects of increased face redness on perceived apology sincerity and likelihood to forgive through the mediator, perceived embarrassment, in Experiment 2. Coefficients are unstandardized estimates, and the coefficients in parentheses are total effects. The indirect effect of face redness on perceived apology sincerity through perceived embarrassment is .60, $p < .001$. The indirect effect on likelihood to forgive through perceived embarrassment is .57, $p < .001$.

Experiment 3

Experiment 2 demonstrated that facial blushing facilitated perceptions of embarrassment, apology sincerity, and likelihood to forgive a transgression, relative to baseline faces for neutral, embarrassed, and ashamed expressions. Further, the results demonstrated that perceived embarrassment mediated the influence of facial blushing on both perceived apology sincerity and likelihood to forgive. In Experiment 3, we aim to assess the influence of facial blushing on the same social evaluations while introducing a new evaluation (perceived anger) and a new pair of emotion expressions (ashamed vs. anger). We chose to use ashamed expressions because they elicited the highest ratings for each of the social evaluations (including perceived embarrassment) in the previous experiment. We chose to introduce anger expressions as a contrast because anger provides disparate social information than embarrassment (e.g., hostility rather than appeasement), so blushing with shame should facilitate perceptions of the focal social evaluations to a greater extent than blushing with anger.

Method

Participants. Ninety-three (75 female, $M_{age} = 20.19$, $SD_{age} = 1.15$) students at a university in the northeast US with color-normal vision participated in the experiment in exchange for extra course credit.

Stimuli. The stimuli for the ashamed expressions were the same as in the previous experiment. We selected an additional two stimulus photographs (1 male, 1 female) from the Radboud Faces Database that were validated as posing anger expressions by past research (Langner et al., 2010). For each photograph, we created 2 versions varying in facial redness by +10 units in CIELAB a^* (redness) in the same way as in Experiment 2. This resulted in a total of 8 stimulus photographs (2 targets \times 2 expressions \times 2 color conditions). See Figure 6 for an example of the stimuli used.

Procedure. Participants completed the experiment on a CRT monitor with the same color-calibration and laboratory conditions described in the previous experiments. Participants completed three separate blocks, one for each of the social evaluations (embarrassment/anger, apology sincerity, and forgiveness). In each block, a pair of faces from the same target identity (baseline vs. increased redness) was displayed side-by-side on the monitor, along with the vignettes used in the previous experiment. Specifically, in the embarrassment/anger block, participants were prompted with the vignette, “You catch this person telling a lie. How embarrassed [angry] does this person look?”. In the sincerity block, participants were prompted with the vignette, “This person apologizes for cheating on a test. How sincere is this person’s apology?”. In the forgiveness block, participants were prompted with the vignette, “This person borrowed your most valued possession, and then lost it. How likely would you be to forgive this person?”. Participants provided ratings for each stimulus photograph on a scale of 1 (not at all) to

9 (very much) on each of the questions for each block. Participants rated each target photograph for each color condition across the two facial expressions, resulting in 32 total trials. Target identity, order within blocks, and side of screen (redder face on left vs. right) were randomized. The perceived embarrassment/anger block was completed first, then the sincerity and forgiveness blocks followed in randomized order.

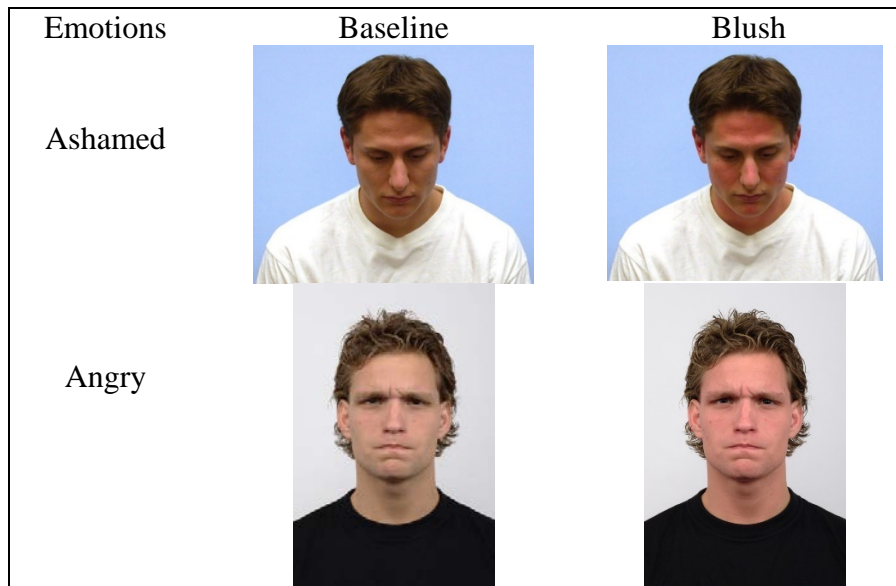


Figure 6. Example stimuli used in Experiment 3.

Results

We conducted $2 \times 2 \times 2$ repeated measures ANOVAs (expression: ashamed, angry \times color: neutral, red \times target identity) for each type of judgment.

Embarrassment. A main effect of facial expression on perceived embarrassment emerged, $F(1, 92) = 72.61, p < .001, \eta_p^2 = .44$, indicating that faces exhibiting an ashamed expression ($M = 5.87, SE = .139$) were perceived as more embarrassed than faces exhibiting an angry expression ($M = 3.90, SE = .203$). There was no effect of target identity, $F(1, 92) = .671, p = .415, \eta_p^2 = .007$. A main effect of color emerged, $F(1, 92) = 147.98, p < .001, \eta_p^2 = .62$, such

that blushed faces were perceived as more embarrassed ($M = 5.77$, $SE = .164$) than baseline faces ($M = 3.99$, $SE = .133$). More central to our current hypotheses, there was a significant expression \times color interaction, $F(1, 92) = 21.35$, $p < .001$, $\eta_p^2 = .19$, indicating that blushing facilitated perceptions of embarrassment to a greater extent for ashamed expressions ($M_{diff} = 2.22$, $SE = .173$), $t(92) = 12.79$, $p < .001$, $d = 1.33$, than for angry expressions ($M_{diff} = 1.34$, $SE = .175$), $t(92) = 7.69$, $p < .001$, $d = .80$.

Anger. A main effect of facial expression on perceived anger emerged, $F(1, 92) = 211.24$, $p < .001$, $\eta_p^2 = .70$, indicating that faces exhibiting an angry expression ($M = 6.07$, $SE = .149$) were perceived as more angry than faces exhibiting an ashamed expression ($M = 3.01$, $SE = .164$). There was a main effect of target identity, $F(1, 92) = 7.45$, $p = .008$, $\eta_p^2 = .08$. A main effect of color emerged, $F(1, 92) = 60.83$, $p < .001$, $\eta_p^2 = .40$, such that blushed faces were perceived as more angry ($M = 5.07$, $SE = .139$) than baseline faces ($M = 4.01$, $SE = .129$). More central to our current hypotheses, there was a significant expression \times color interaction, $F(1, 92) = 8.60$, $p = .004$, $\eta_p^2 = .09$, indicating that blushing facilitated perceptions of anger to a greater extent for angry expressions ($M_{diff} = 1.34$, $SE = .172$), $t(92) = 7.80$, $p < .001$, $d = .81$, than for ashamed expressions ($M_{diff} = .78$, $SE = .161$), $t(92) = 4.84$, $p < .001$, $d = .50$.

Apology sincerity. A main effect of facial expression on apology sincerity emerged, $F(1, 92) = 256.39$, $p < .001$, $\eta_p^2 = .74$, indicating that faces exhibiting a shame expression ($M = 6.11$, $SE = .165$) were perceived as more sincere than faces exhibiting an angry expression ($M = 2.42$, $SE = .138$). There was a main effect of target identity, $F(1, 92) = 9.43$, $p = .003$, $\eta_p^2 = .09$. A main effect of color emerged, $F(1, 92) = 7.37$, $p = .008$, $\eta_p^2 = .07$, such that blushed faces were

perceived as more sincere ($M = 4.45$, $SE = .121$) than baseline faces ($M = 4.07$, $SE = .121$). More central to our current hypotheses, there was an expression \times color interaction (although this interaction was only marginally significant), $F(1, 92) = 2.79$, $p = .098$, $\eta_p^2 = .03$, indicating that blushing facilitated perceptions of apology sincerity to a greater extent for ashamed expressions ($M_{diff} = .54$, $SE = .212$), $t(92) = 2.57$, $p = .012$, $d = .27$, than for angry expressions ($M_{diff} = .22$, $SE = .116$), $t(92) = 1.90$, $p = .060$, $d = .20$.

Likeliness to forgive. A main effect of facial expression on likeliness to forgive emerged, $F(1, 92) = 212.76$, $p < .001$, $\eta_p^2 = .70$, indicating that participants were more likely to forgive targets exhibiting a shame expression ($M = 5.92$, $SE = .183$) than targets exhibiting an angry expression ($M = 2.71$, $SE = .176$). There was a main effect of target identity, $F(1, 92) = 26.36$, $p < .001$, $\eta_p^2 = .22$. A main effect of color emerged, $F(1, 92) = 14.54$, $p < .001$, $\eta_p^2 = .14$, such that blushed faces were more likely to be forgiven ($M = 4.58$, $SE = .157$) than baseline faces ($M = 4.06$, $SE = .158$). More central to our current hypotheses, there was a significant expression \times color interaction, $F(1, 92) = 10.97$, $p = .001$, $\eta_p^2 = .11$, indicating that blushing facilitated likeliness to forgive to a greater extent for ashamed expressions ($M_{diff} = .77$, $SE = .177$), $t(92) = 4.34$, $p < .001$, $d = .45$, than for angry expressions ($M_{diff} = .27$, $SE = .131$), $t(92) = 2.09$, $p = .039$, $d = .22$. See figure 7 for a summary of the results from Experiment 3.

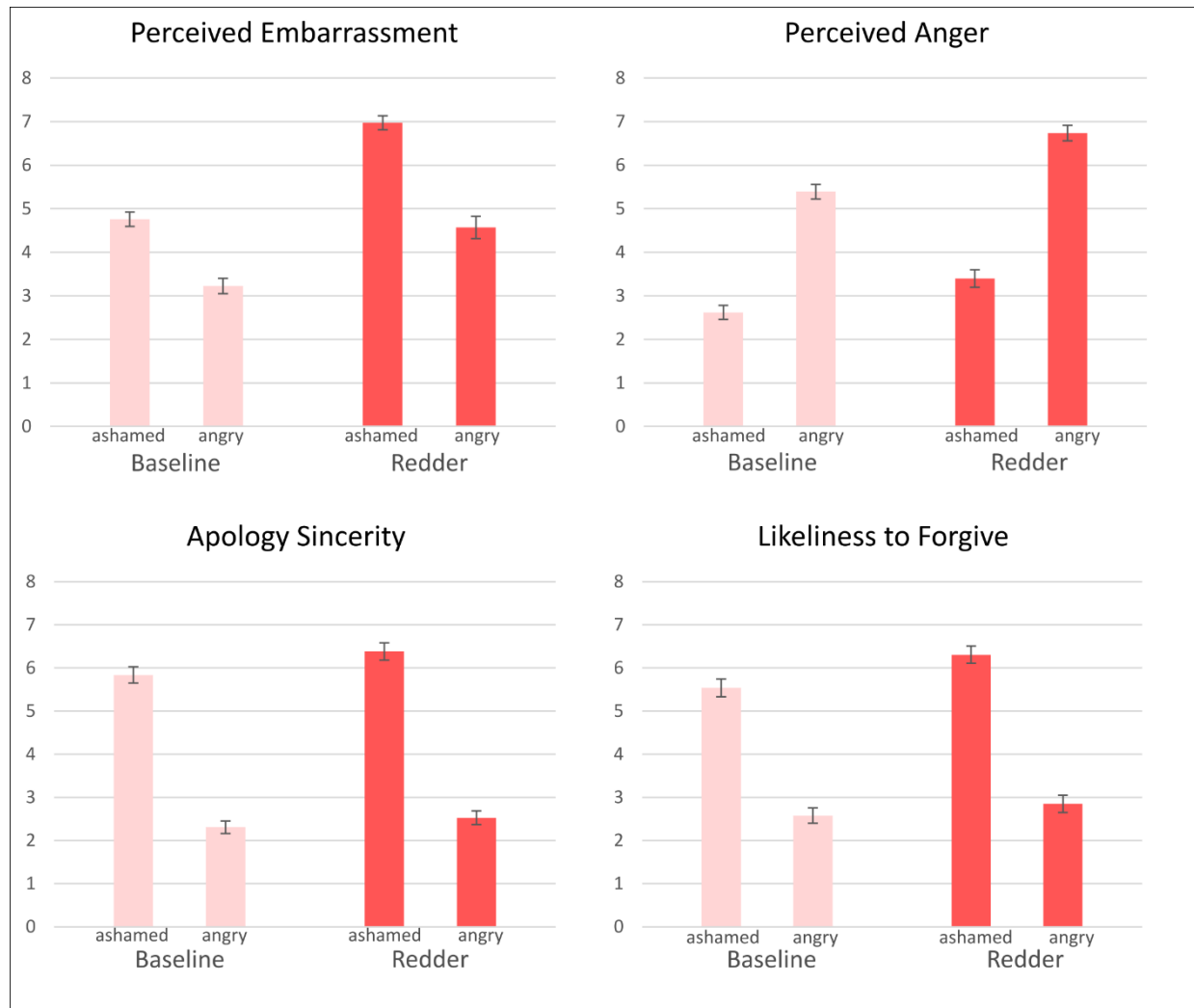


Figure 7. Mean and standard error of ratings made in Experiment 3.

Mediation analyses. Next, we tested a series of mediation models to determine whether facial redness would increase apology sincerity and likelihood to forgive via perceived embarrassment and anger (as parallel mediators), separately for ashamed and anger expressions. We computed composite scores that averaged participant ratings for each dependent variable, collapsing across target identity, for each facial expression. Then we used *MEMORE* (Montoya & Hayes, 2017) for SPSS to explore indirect effects of blushing on sincerity/forgiveness via

perceived embarrassment and anger. Ninety-five percent confidence intervals were generated from 5,000 bootstrap samples and are reported in brackets for each result below.

Apology sincerity for ashamed expressions. The total effect of blushing on perceived apology sincerity was significant ($c = .54$ [.12, .96], $p = .012$), indicating that blushing increased perceived apology sincerity for people displaying shame. The blushing targets were also perceived as more embarrassed ($a_1 = 2.22$ [1.87, 2.56], $p < .001$) and angry ($a_2 = .78$ [.46, 1.10], $p < .001$) than the baseline targets. The relationship between perceived embarrassment and apology sincerity was marginally significant ($b_1 = .24$ [-.02, .50], $p = .073$), such that greater perceived embarrassment tended to predict greater perceived sincerity. No relationship between perceived anger and apology sincerity emerged ($b_2 = .07$ [-.22, .36], $p = .65$). Neither of the indirect effects were significantly different from zero ($a_1b_1 = .53$ [-.16, 1.37], $p = .17$; $a_2b_2 = .05$ [-.20, .29], $p = .67$). A contrast comparing the indirect effects was not significant ($contrast = .47$ [-.30, 1.37], $p = .27$). Finally, after accounting for the mediators, the direct effect of blushing on perceived sincerity was not significantly different from zero ($c' = -.04$ [-.74, .67], $p = .92$).

Likelihood to forgive for ashamed expressions. The total effect of blushing on likelihood to forgive was significant ($c = .77$ [.42, 1.12], $p < .001$), indicating that participants were more likely to forgive blushing faces than baseline faces. The relationship between perceived embarrassment and likelihood to forgive was significant ($b_1 = .34$ [.13, .55], $p = .002$), such that greater perceived embarrassment positively predicted higher forgiveness likelihood. No relationship emerged between perceived anger and forgiveness likelihood ($b_2 = -.04$ [-.27, .20], $p = .76$). The indirect effect of blushing on forgiveness likelihood via perceived embarrassment was significantly different from zero ($a_1b_1 = .75$ [.26, 1.46], $p = .015$), but the indirect effect via perceived anger was not ($a_2b_2 = -.03$ [-.25, .17], $p = .78$). A contrast comparing the indirect

effects revealed a significant difference ($contrast = .78$ [.21, 1.55], $p = .024$). After accounting for the mediators, the direct effect of blushing on forgiveness was not significantly different from zero ($c' = .04$ [-.53, .62], $p = .88$). See Figure 8 for a summary of the mediation analyses for ashamed expressions.

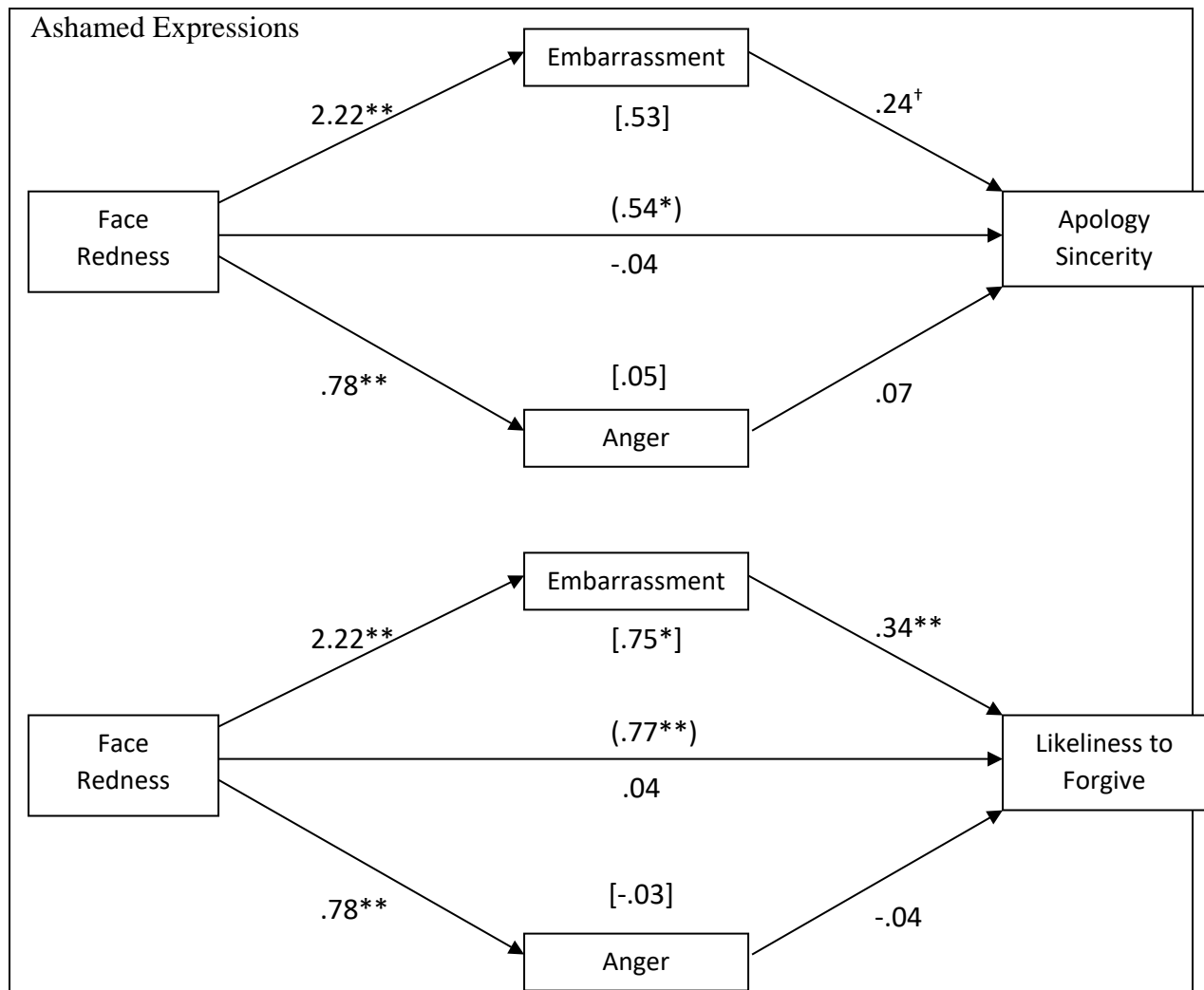
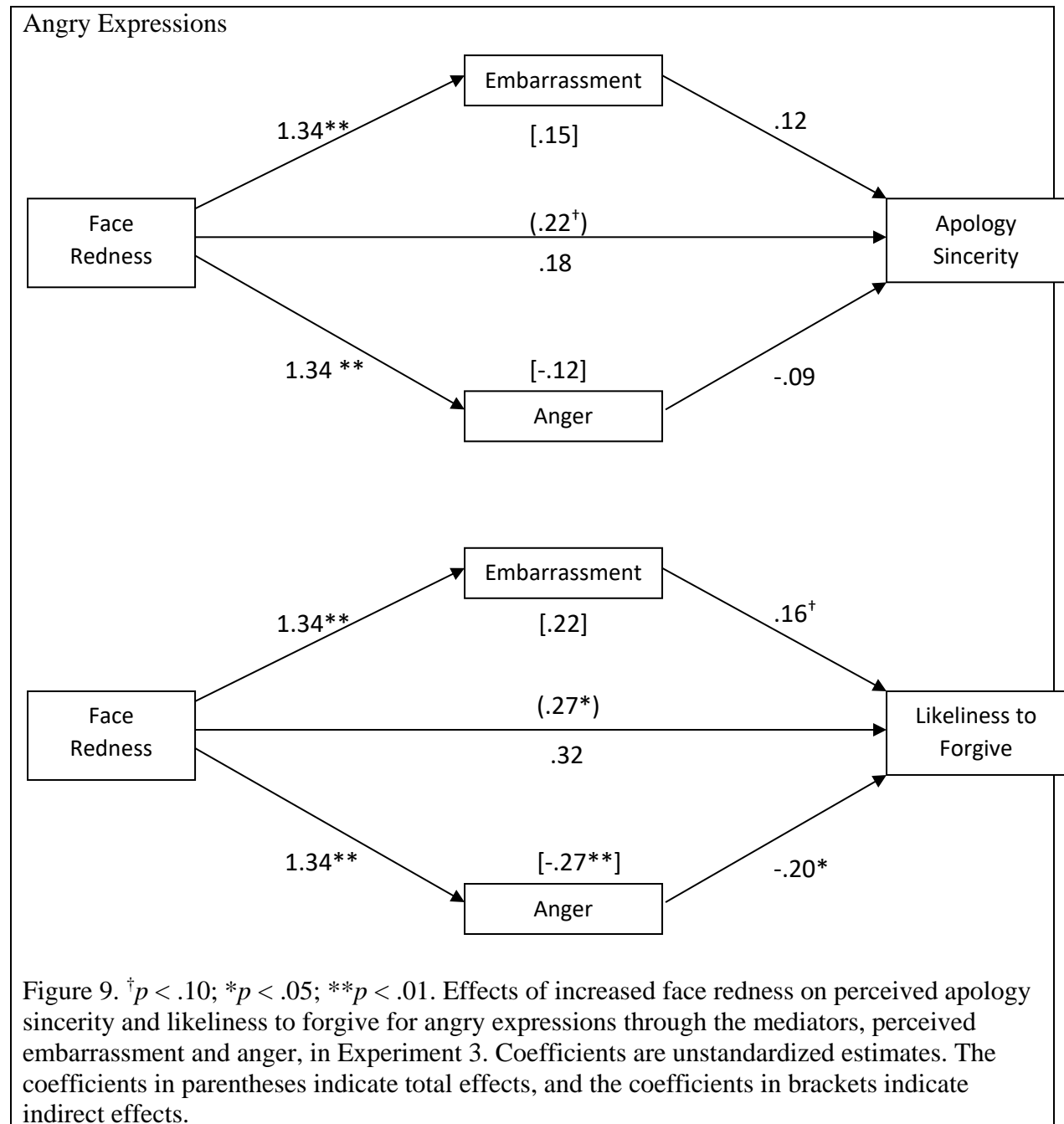


Figure 8. $^{\dagger}p < .10$; $*p < .05$; $**p < .01$. Effects of increased face redness on perceived apology sincerity and likelihood to forgive for ashamed expressions through the mediators, perceived embarrassment and anger, in Experiment 3. Coefficients are unstandardized estimates. The coefficients in parentheses indicate total effects, and coefficients in brackets indicate indirect effects.

Apology sincerity for angry expressions. The total effect of blushing on perceived apology sincerity was marginally significant ($c = .22 [-.01, .45]$, $p = .06$), indicating that blushing tended to increase perceived sincerity for people displaying anger. Blushing also led to greater perceived embarrassment ($a_1 = 1.34 [1.00, 1.69]$, $p < .001$) and anger ($a_2 = .1.34 [1.00, 1.68]$, $p < .001$). The relationship between perceived embarrassment and apology sincerity was not significant ($b_1 = .12 [-.04, .27]$, $p = .15$), nor was the relationship between perceived anger and apology sincerity ($b_2 = -.09 [-.23, .06]$, $p = .23$). Neither of the indirect effects were significantly different from zero ($a_1b_1 = .15 [-.09, .46]$, $p = .27$; $a_2b_2 = -.12 [-.34, .09]$, $p = .29$). A contrast comparing the indirect effects was not significant ($contrast = .27 [-.09, .71]$, $p = .19$). Finally, the direct effect was not significantly different from zero after accounting for the mediators ($c' = .18 [-.16, .52]$, $p = .29$).

Likelihood to forgive for angry expressions. The total effect of blushing on likelihood to forgive was significant ($c = .27 [.01, .53]$, $p = .039$), indicating that people are more likely to forgive blushed targets displaying an anger expression. The relationship between perceived embarrassment and likelihood to forgive was marginally significant ($b_1 = .16 [-.006, .34]$, $p = .058$), suggesting that greater perceived embarrassment tended to predict a greater likelihood to forgive. The relationship between perceived anger and forgiveness was significant in the opposite direction, such that greater perceived anger led to lower forgiveness likelihood ($b_2 = -.20 [-.35, -.05]$, $p = .01$). The indirect effect via perceived embarrassment was not significantly different from zero ($a_1b_1 = .22 [-.02, .49]$, $p = .10$), but the indirect effect via perceived anger was significant ($a_2b_2 = -.27 [-.46, -.08]$, $p = .005$). A contrast comparing the indirect effects revealed a significant difference ($contrast = .49 [.16, .84]$, $p = .005$). The direct effect of blushing

on forgiveness likelihood was marginally significant after accounting for the mediators ($c' = .32$ $[-.04, .69]$, $p = .08$). See Figure 9 for a summary of the mediation analyses for angry expressions.



General Discussion

Altogether, the results across three experiments demonstrate that blushing facilitates perceptions of embarrassment, apology sincerity, and likeliness to forgive. In Experiments 1 and

2, these evaluations were made when the context was that of appeasement (i.e., instructions and expressions were related to appeasement). In Experiment 3, blushing facilitated perceptions of embarrassment, apology sincerity, and likeliness to forgive to a greater extent for ashamed expressions than for angry expressions, suggesting that emotion context jointly modified the role of facial color in social perception when disparate contextual information was present. These results support the notion that facial color can convey social information necessary for a social functional account of emotion perception in others.

The mediation analyses in the current work may also point to specificity regarding the social influence of blushing in the context of embarrassment. In Experiment 2, perceived embarrassment mediated the effects of blushing on sincerity and forgiveness, indicating that facial color can cue perceivers to others' emotional state, which then leads to corresponding judgments and perceptions of behavioral intentions. However, in Experiment 3, perceptions of embarrassment did not mediate the effects of blushing on apology sincerity. We speculate that blushing facilitates the perceived authenticity of emotion, a path that is not specific to embarrassment. For instance, blushing occurs for both expressions of embarrassment and anger as a consequence of underlying physiological reactivity. Therefore, a blush response is less amenable to deliberate control than facial-muscular expressions, and thus less able to be feigned. Because blushing facilitated perceptions of the respective emotions (i.e., blushing made ashamed expressions look more embarrassed, and made anger expressions look more angry), it could be the case that blushing signals a more authentic, honestly felt emotion (whether it be embarrassment, anger, or another emotion) thereby demonstrating a more sincere apology (even if expressing anger is not a functional apologetic strategy). Further, in Experiment 3, perceptions of embarrassment mediated the effects of blushing on forgiveness for ashamed expressions,

while perceptions of anger mediated the effects of blushing on forgiveness for angry expressions. This pattern of results indicated that not only were blushing ashamed expressions viewed as more embarrassed leading to increased likeliness to forgive, but also that blushing angry expressions were viewed as more angry leading to decreased likeliness to forgive. Altogether, these results indicate that perceived embarrassment and anger are both consequences of blushing, and that the influence of blushing on social evaluations relies on the context (in this case disparate emotion expressions) in which they are evaluated.

Social functional accounts of emotion hold that emotional expressions (and the capacities to perceive them) evolved because of the advantages they afford in solving distinct social problems inherent in the social environment (Keltner, Haidt, & Shiota, 2006). The expression of the blush (in the form of facial redness) serves such a social function, in that it communicates to others that we value their social evaluation, therefore appeasing and minimizing social disapproval and potential social exclusion (Castelfranchi & Poggi, 1990; De Jong, 1999). Likewise, detecting subtle emotional expressions in others serves an adaptive social function. For instance, facial color expressions of emotion (including the blush) are a result of underlying hemodynamic processes (see Thorstenson, 2018). It has been posited that human trichromatic color vision may have been selected by social evolutionary pressures to better detect and discriminate the underlying social state (e.g., emotions) of others (Changizi, Zhang, & Shimojo, 2006), in order to adaptively interpret and respond to the social environment.

Therefore, the current work provides supportive evidence that perceptions of facial color adaptively serve the social function of detecting emotional states (i.e., embarrassment) in others. Further, the current work points to a potential unique social functional account of facial color in perceptions of emotion. Specifically, while there are more noticeable expressions of emotion

(e.g., facial-muscular expressions), facial-color expressions are a subtle, yet inevitable consequences of underlying physiological processes, like blood flow. However, while facial-muscular expressions (e.g., smiles, frowns) can be readily feigned, changes in blood flow (and resulting skin color appearance) are less amenable to deliberate control. Therefore, changes in facial color (including the blush) might uniquely serve as an ‘honest’ signal of emotion, enhancing the perceived authenticity of an emotional expression. The results from the current research support this hypothesis, considering that facial redness facilitated perceptions of embarrassment (for neutral, embarrassed, and ashamed expressions), anger (for angry expressions), apology sincerity, and likeliness to forgive a transgression.

A limitation of the current work is that our color manipulation was administered within-subjects using side-by-side photographs of the same target identities. This likely made color differences more salient than if targets were viewed in isolation, which more closely resembles how people are perceived in actual real-world encounters. However, detecting a blush response requires a comparison to baseline skin color, as blushing is a transient phenomenon in which facial color changes occur rapidly over a brief duration of time (Changizi, 2006). Therefore, within-subjects comparisons (or some design incorporating a dynamic comparative sequence) are required when utilizing static images, as was done in the present research. Future investigations examining differing levels of dynamic skin color changes in a between-subjects research design would provide complementary information regarding how skin color influences perceived emotion, along with downstream consequences of inferring others' emotional states.

Another limitation is that the supplementary replication of Experiment 1 (Footnote 1) was conducted using an online sample. This approach should be considered a limitation given that participants completed the experimental procedure on their own monitors, which could not be

calibrated to ensure careful colorimetric displays of the stimuli. This limitation may be evident considering the smaller effect sizes observed relative to the more rigorously controlled Experiment 1, and the non-significant effect of blushing on perceived apology sincerity. Nevertheless, in Experiments 1, 2, and 3, we utilized a well-controlled laboratory setting, which allowed us to assess the generalizability of the findings by comparing a laboratory sample to an online one (for a discussion of the limitations as well as merits of this approach, see Thorstenson, 2018). Finally, it is evident that blushing on the face (with embarrassment and other emotions) occurs heterogeneously, both in the regions of the face that change, and in the amount of color that changes across the face (Benitez-Quiroz, 2018; Drummond, 2012). However, we manipulated faces holistically with color changes occurring across the entire face. While this approach may be considered as parsimonious, more colorimetric data is needed to elucidate the regional (i.e., areas of the face) and descriptive (i.e., amount of color change) specificity of color changes occurring across the face with emotion, and future work should aim to incorporate stimuli consistent with these emotion-specific patterns.

An unexpected pattern of results emerged in Experiment 2, such that embarrassed expressions elicited lower sincerity and forgiveness ratings than neutral facial expressions. We speculate that this could possibly be due to the observation that embarrassed expressions include a smile, which could diminish perceptions of sincerity. In line with this speculation, previous work using comparable stimuli (Dijk et al., 2011) found a similar pattern, such that embarrassed expressions were not perceived as more embarrassed than neutral stimuli, but that they were perceived as more amused. However, this could additionally point toward evidence of the notion that face color might serve to uniquely signal emotion authenticity, given that blushing facilitated perceptions of emotion within the disparate expressions. Finally, while the current research only

investigated perceptions of facial blushing due to negative social attention, it is worth noting that the blush is also elicited by unwanted positive social attention (e.g., in the case of praise; Nikolić et al., 2018). We expect that perceptions of blushing in this context would similarly serve to facilitate related social functional evaluations, although more research is needed to test this hypothesis.

In sum, the current research highlights the utility of facial color as a social communicative tool, the role of facial color in emotion expression, and provides support for a social functional account of facial color in emotion communication. Additional research is warranted to further investigate the unique utility of perceiving facial color as an indicator of socially relevant states.

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